International Journal of Digital Crime and Forensics
Volume 10 • Issue 1 • January-March 2018

Geometrically Invariant Image Watermarking Using Histogram Adjustment

Zhuoqian Liang, College of Information Science and Technology, Jinan University, Guangzhou, China

Bingwen Feng, College of Information Science and Technology, Jinan University, Guangzhou, China

Xuba Xu, College of Information Science and Technology, Jinan University, Guangzhou, China

Xiaotian Wu, Department of Computer Science, Jinan University, Guangzhou, China, and State Key Laboratory of Information Security, Institute of Information Engineering, Chinese Academy of Sciences, Beijing, China

Tao Yang, Key Lab of Information Network Security, Ministry of Public Security, Shanghai, China

ABSTRACT

In this article, a blind image watermarking scheme, which is a robust against common image processing and geometric attacks is proposed by adopting the concept of histogram-based embedding. The average filter is employed to low-pass pre-filter the host image. The watermark bits are embedded into the histogram of the low-frequency component and the template bits are embedded in the high-frequency residual. The embedding is performed by adjusting the value of two consecutive histogram bins. Furthermore, a post-quantization is employed after the embedding round to improve robustness. All pixel modifications incurred are based on the human visual system (HVS) characteristics. As a result, a good tradeoff between robustness and imperceptibility is achieved. Experimental results reported the satisfactory performance of the proposed scheme with respect to both common image processing and geometric attacks.

KEYWORDS

Blind Watermarking, Geometric Attacks, Histogram-Based Embedding, Human Visual System

1. INTRODUCTION

Digital media has been widely used for information communication and dissemination. However, with the rapid development of the internet and the multimedia process technique, it becomes easy to manipulate and distribute digital media illegally. Digital watermarking is a promising technique to actively prevent these infringements. It embeds messages into digital arts for security purposes such as ownership protection and content verification. Robustness is a critical characteristic for a watermarking system. It calls for that the embedded watermarks should survive common signal processing, geometric attacks, and so on (Voloshynovskiy, Pereira, Iquise, & Pun, 2001).

Many image watermarking schemes have been developed for the robustness against common signal processing. By embedding watermark bits into the low-frequency component, such as the DC component of discrete cosine transform (Huang, Shi, & Shi, 2000), the approximate subband of discrete wavelet transform (Akhaee, Sahraeian, & Jin, 2011), the low-pass filtered image (Xiang, Kim, & Huang, 2008; Zong et al., 2015), etc., a watermark system can achieve considerable robustness against image processing operations. Furthermore, data hiding codes considering human visual system (HVS) characteristics (eg, just noticeable difference (JND) (Lewis & Knowles, 1992) and

DOI: 10.4018/IJDCF.2018010105

structural similarity index (SSIM) (Wang & Bovik, 2004) have also been developed to enhance embedding energy while preserving watermarked image quality (Feng, Sun, Huang, & Shi, 2016). Unlike common signal processing operations, geometric attacks intend to break the synchronization with the embedded information (Voloshynovskiy et al., 2001). Thus, aforementioned techniques appear to be brittle against this type of attacks. Achieving the robustness against geometric attacks remains a challenge especially for blind image watermarking systems.

Watermarks embedded in geometrically invariant domain naturally survive the corresponded geometric attacks. A well-known pioneering work is the Fourier-Mellin transformation, which is designed to be invariant to global rotation, translation, and scaling (RST) (Ruanaidh & Pun, 1998). Uniform Log-Polar Mapping is also suggested for the robustness against geometric attacks (Kang, Huang, & Zeng, 2010). The scheme in (L. Li, S. Li, Abraham, & Pan, 2012) embeds watermark bits into the magnitudes of polar harmonic transform to achieve rotation and scaling invariance. In (Tian, Zhao, Ni, Qin, & Li, 2013), local daisy feature transform is developed to obtain both globally and locally invariant space. Moment invariants can be also considered as the watermark embedding domain (Zhang et al., 2011). Some schemes exploit the histogram shape of an image to carry watermark bits (Xiang et al., 2008; Zong et al. 2015). Compared with the other approaches, histogram can be extracted more easily and does not require additional synchronization. As a result, the computational cost of the watermarking system is low, and there will be less detection errors caused by incorrect synchronization. Motivated by this, our scheme also employs the histogram as the embedding domain.

In this paper, a blind robust image watermarking is proposed by adopting histogram-based embedding. Noting that the histogram of an image may be sensitive to common image processing, schemes in (Xiang et al., 2008) and (Zong et al. 2015) employ Gaussian low-pass pre-filtering to generate the low-frequency component from the host image first. However, due to the side effect of the over-sampling in the Gaussian filtering, there will be strong self-influence that cannot be eliminated during watermark embedding. In view of this, the proposed scheme opts the average filtering followed by a down sampling. This allows the perfect recovery of the watermarked low-frequency component. We also embed template bits into the high-frequency residual to resynchronize the watermarked image. Furthermore, a novel pixel modification strategy considering HVS is adopted to perceptually handle the embedding distortion, which improves the watermarked image quality.

2. WATERMARK EMBEDDING

2.1. Low and High Frequency Component Extraction

Watermark bits are usually suggested to be embedded in low frequency for the robustness against common signal processing (Huang et al., 2000; Zong et al. 2015). In view of this, given an $m_I \times n_I$ sized host image I, it is successively passed through an average filtering and a down sampling to compute the $m_I / 2 \times n_I / 2$ sized low-frequency component (also referred to as the low-pass filtered image) I_{low}, written as

$$I_{low}\left(x,y\right)=\frac{1}{4}\left(I\left(2x,2y\right)+I\left(2x+1,2y\right)+I\left(2x,2y+1\right)+I\left(2x+1,2y+1\right)\right) \tag{1}$$

where $I_{low}\left(x,y\right)$, $x\in\left\{0,...,m_I/2-1\right\}$, $y\in\left\{0,...,n_I/2-1\right\}$, denotes the value of the $\left(x,y\right)$-th coefficient in $\mathrm{I_{low}}$. The corresponding high-frequency residual I_{high}, which is of size $m_I\times n_I$, can then be obtained as